A RADIAL ELECTROD
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A RADIAL ELECTRODE FOR CONTINUOUSLY MEASURING THE MOISTURE CONTENT OF SEED COTTON

By Gino J. Mangialardi, Jr., and Anselm C. Griffin, Jr.[1]

ABSTRACT

A radial electrode constructed as a part of the standard, star-shaped, steel feed rollers located in the master feed-control hopper was designed and shown to be a satisfactory device for measuring the moisture content of seed cotton and fiber. The radial-electrode system was calibrated and tested on 23 bales of cotton; it measured a moisture range of 6.7% to 17.2% for seed cotton and 5.2% to 9.2% for fiber. The system was also tested as a moisture-control system. Four drying-path combinations in two 24-shelf tower driers were available for automatic routing of the damp cotton, and a feeder chute and humid air for moistening cotton below 7.5% moisture content.

INTRODUCTION

Automatic systems are now commonly used to control the moisture content of seed cotton during ginning. The degree of control is greatly influenced by the accuracy of the moisture-measuring subsystem, and the U.S. Cotton Ginning Laboratory has shown that the moisture content of cotton fibers can be effectively determined by electrical resistance measurements.[2] Most gins use this principle and measure continuously the electrical resistance of seed cotton passing between two electrodes.

Experiments using an entire feed roller in a hopper as an electrode showed that cotton lodged between the ends of the electrode and that the hopper walls gave false measurements. Also, the full-width electrode was overly sensitive to minor wet spots in the incoming cotton; a shorter electrode was more suitable for measuring the average moisture content of the cotton. Other investigations that compared the performance of a rotating feed-roller electrode to that of fixed, wall-mounted electrodes showed that measurements with a rotating electrode were less affected by the quantity of cotton in the feeder hopper.[3]

These observations led to the conclusion that an electrode satisfactory for measuring moisture could be designed as a section of one of the feed rollers in the feeder, with the other rollers and hopper walls as the "ground" electrodes. This report describes the development of a more sensitive, radial (star-shaped) electrode for universal use with the electrical resistance method for continuously monitoring the moisture content of cotton during ginning.

ELECTRODE DESIGN

A radial electrode (the "hot" or "signal" electrode), constructed as a part of the standard, star-shaped, steel feed rollers located in the master feed-control hopper, makes intimate contact

[1] Agricultural engineer and research physicist, respectively, U.S. Cotton Ginning Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Stoneville, Miss. 38776.

[2] Griffin, A. C., Jr., and Mangialardi, G. J. 1961. Automatic control of seed cotton drying at cotton gins, a review of research. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 42-57, 14 pp.

[3] Mangialardi, Gino J., Jr., and Griffin, A. Clyde, Jr. Electrodes for continuously measuring cotton moisture content at ginneries. U.S. Dep. Agric. Prod. Res. Rep. No. 128, 17 pp.

with cotton as it enters the seed-cotton processing system (fig. 1). The electrode was designed to have the same configuration as the feed rollers and was mounted as a separate insulated section in the center of one of these (fig. 2). This electrode is plated with layers of copper, nickel, and chrome, in that order, to prevent oxidation and to minimize the tendency of cotton to cling to it.

The signal electrode is insulated from the shaft and side sections of the feed roller by acrylic plastic mounts (fig. 3) to which the electrode is attached by aluminum bolts threaded into vertical and horizontal portions of the mounts; the side sections of the feed roller are attached to the mounts in like manner. The electrode is 7 inches in diameter and 7 inches long; the acrylic plastic insulator between the electrode and the remainder of the feed roller is 0.75 inch wide. An insulated wire passing through the hollow roller electrically connects the electrode to a bronze fitting at the end of the shaft, where a carbon brush assembly connects the electrode system to the moisture-measuring instrument (fig. 4).

A companion counterrotating feed roller provides a bearing surface against which the electrode roller works to maintain a relatively constant pressure on cotton passing between them.

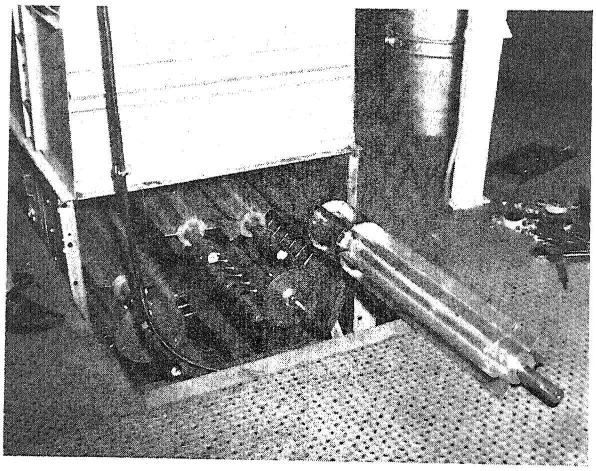
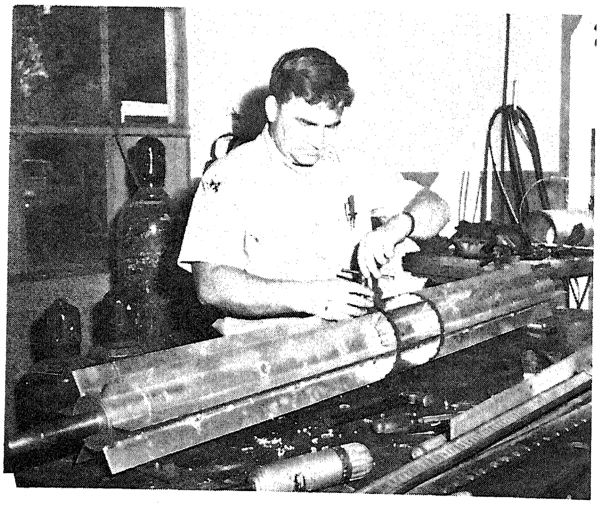


FIGURE 1.—Installation of the radial electrode as one of the feed rollers in the master feed-control hopper.



IGURE 2.—Installation of the signal electrode at center of feed roller. Insulated bronze fitting at end of roller shaft in foreground.

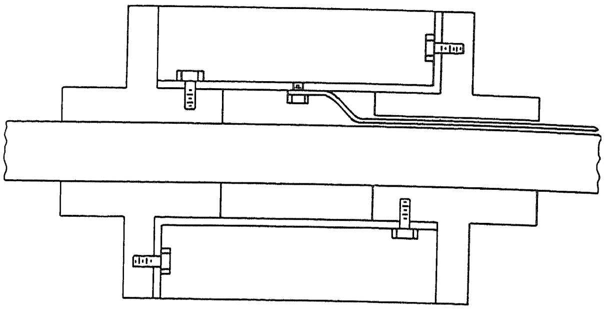


FIGURE 3.—Relationship of signal electrode to acrylic plastic mounts.

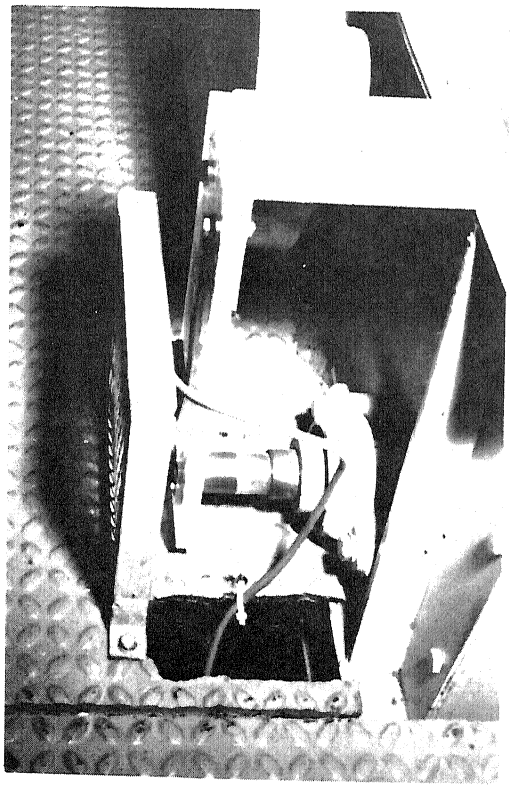


FIGURE 4.—Carbon brush assembly used to collect electrode signal from insulated fitting at end of shaft.

The electrical resistance circuit extends from the signal electrode through the cotton mass to the grounded companion roller, and simultaneously to the side sections of the electrode roller that are at ground potential.

A commercial moisture detector used to measure the electrical resistance of seed cotton passing between the two electrodes reported the electrical resistance as a 0- to 10-millivolt output. This was transmitted to a chart recorder graduated as a 0 to 100 division scale and calibrated to correspond to electrical resistance.

CALIBRATION AND PERFORMANCE

The radial-electrode system was calibrated to measure both seed-cotton and fiber moisture. Twenty-three bales of cotton representing a wide range of moisture contents were used to establish the calibration. This cotton was harvested by spindle pickers and contained foreign matter typically present in normal cotton production. Moisture-content levels were varied by monitoring ambient relative humidity in the field and harvesting at selected periods, and by controlling the amount of water applied to the cotton harvester spindles.

During calibration the processing rate of seed cotton averaged three bales per hour. The feeder electrodes turned at 1 revolution per minute, giving a mean density of 9.6 pounds per cubic foot for seed cotton passing between the electrodes. The height of cotton in the hopper was maintained at about 4 feet by means of a conventional automatic overflow control switch.

Cotton moisture was quantitated in samples collected as cotton passed through the feed rollers and in lint obtained by hand ginning portions of the seed-cotton sample.[4] The moisture range of seed cotton from the 23 bales was 6.7% to 17.2% (table 1). The equivalent moisture range for fiber was 5.2% to 9.2%. Moisture levels higher or lower than these were not necessary because a fiber moisture level of 5.2% is too low and 9.2% is too high for proper ginning; at these levels the detector would indicate a need for remedial action.

[4] American Society for Testing and Materials. Standard method of test for moisture in cotton by oven-drying. ASTM Designation: D 2495–70. Philadelphia, The Society.

TABLE 1.—*Moisture content and detector-recorder reading obtained for 23 calibration bales processed by the radial electrode*[1]

Calibration bale No.	Moisture content, wet base[2] (%) Seed cotton	Moisture content, wet base[2] (%) Hand-ginned lint	Detector-recorder reading (millivolts)
1	17.2	9.2	9.8
2	16.3	7.7	9.9
3	15.8	9.0	9.9
4	14.4	8.3	9.7
5	14.3	8.2	9.9
6	14.3	6.9	8.6
7	14.0	7.7	9.9
8	11.2	6.9	5.7
9	11.1	5.8	3.8
10	10.9	5.9	6.6
11	10.7	5.8	3.3
12	10.7	5.3	5.2
13	10.3	7.2	7.7
14	10.2	5.9	1.3
15	10.0	5.9	2.5
16	9.5	5.7	5.8
17	9.4	6.1	4.4
18	8.7	5.5	2.7
19	8.4	5.6	2.0
20	8.3	4.8	.8
21	7.6	5.0	.1
22	6.7	5.9	.0
23	6.7	5.2	.0

[1] Data for each bale represent an average of 5 samplings.

[2] Moisture content was determined by ovendrying, ASTM method D 2495–70.

Precision instruments were used to calibrate the electrical resistance across the instrument input terminals and its millivoltage response. By means of appropriate equations, the actual electrical resistance of the cotton between the electrodes was converted to equivalent moisture contents of seed cotton or lint. Regression analyses of the data were used to determine the average linear relationship of the amount of cotton moisture to electrical resistance (fig. 5). These data are valid only for the electrode system described here, but they show that the rate of change of moisture content with change in electrical resistance is greater for seed cotton than for cotton fibers and can be used to satisfactorily control gin driers.

During a 3-year period more than 800 bales of cotton passed through the radial-electrode feed rollers with no mechanical or electrical problems.

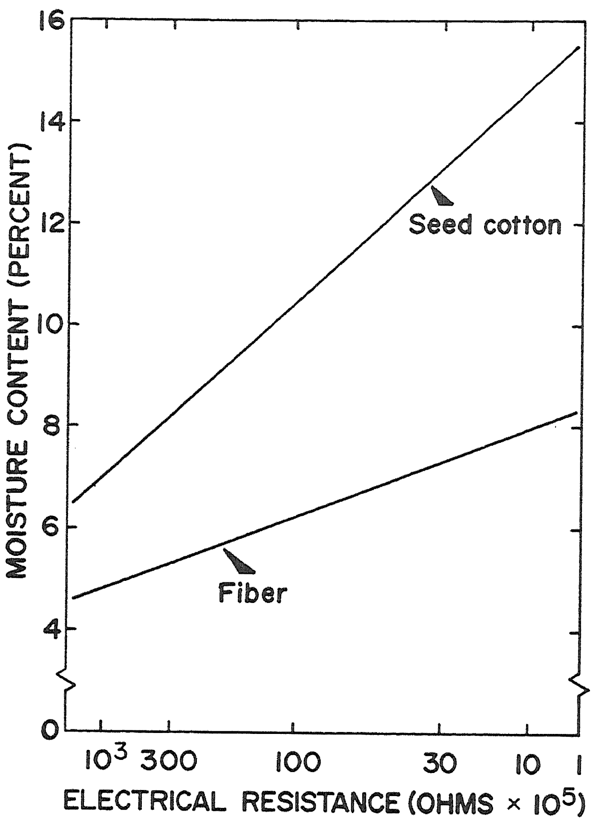


FIGURE 5.—Moisture content of seed cotton and fiber versus measured electrical resistance of rotating radial electrode.

APPLICATION

In conjunction with studies on cotton drying and moisture restoration, the system has been used to automatically select alternate drying routes through experimental driers based on the cotton's need for drying, and to activate the moisture restoration apparatus when the detector indicates a cotton moisture content too low for proper ginning (fig. 6 and table 2). This was accomplished by installing cam-operated electric switches on the pen motor hub of the recorder

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and was routed through all or part of the second drier.

The route change valve above the first drier routed cotton through 24 shelves of drier No. 1 when the detector measured seed-cotton moisture at 14.5% or more; this corresponds to 90 divisions of the recorder chart scale. Seed cotton containing less than 14.5% moisture passed through the bottom shelf of tower drier No. 1 and was routed through the 1-, 13-, or 24-shelf drying path of drier No. 2.

When the detector measured seed-cotton moisture at 7.5% or less (this corresponds to 10 divisions of the recorder chart scale), humid air was directed through a feeder chute where the air mixed with the seed cotton, enabling fibers to absorb moisture. When seed-cotton moisture was more than 7.5%, the humid air bypassed the chute and was exhausted outside the gin plant. The feeder chute was located between distributor and extractor feeder and required no special routing of cotton.

Misting nozzles were later installed in the con-

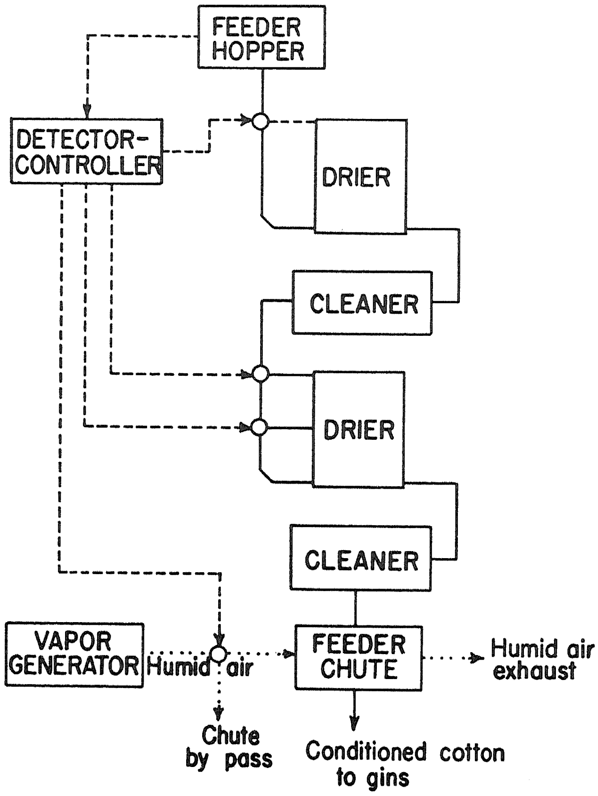

FIGURE 6.—Block diagram of the automatic moisture-conditioning system controlled by the rotating radial electrode.

veyor-distributor to add greater amounts of moisture to the low-moisture cottons. These are activated automatically in conjunction with the humid air subsystem. The need for quality control of cotton during ginning prompts the continuation of this work.

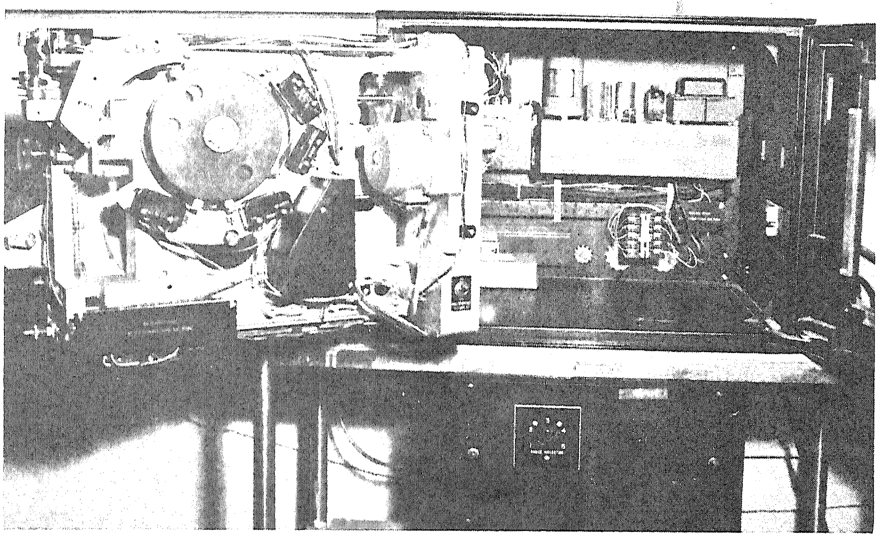

FIGURE 7.—Detector-controller used with radial-electrode subsystem. Cam-operated switches mounted on the pen motor hub of the recorder are shown in left foreground.

TABLE 2.—*Performance of automatic moisture-conditioning system on 14 experimental bales*[1]
[System controlled by rotating radial electrode]

Initial seed-cotton moisture content[2] (%)	Ambient relative humidity (%)	Conditioning path[3]: Drier No. 1 (shelves)	Conditioning path[3]: Drier No. 2 (shelves)	Conditioning path[3]: Moisture vapor delivery	Moisture content after conditioning (%): Seed cotton[4]	Moisture content after conditioning (%): Lint[5]
16.3	52	24	24	Bypass	13.1	7.5
15.8	70	24	24	Bypass	11.3	8.0
14.3	53	24	24	Bypass	11.9	6.3
14.0	57	24	24	Bypass	12.3	8.1
11.2	55	1	13	Bypass	11.4	6.8
10.7	57	1 1	1 13	Bypass Bypass	8.0	5.6
10.2	32	1 1	1 1	Bypass Chute	7.4	4.4
9.5	36	1 1	13 24	Bypass Bypass	7.3	5.5
9.4	56	1 1	1 13	Bypass Bypass	7.0	4.8
8.4	36	1	1	Bypass	6.9	5.5
8.3	60	1 1	1 1	Bypass Chute	7.5	5.7
7.6	62	1	1	Chute	6.2	4.1
6.7	64	1	1	Chute	6.2	4.2
6.7	60	1	1	Chute	6.5	4.3

[1] Data for each experimental bale represent an average of 5 samplings. [2] Sampled from the feed-controller hopper. [3] Where 2 paths are shown, the controller changed path during the bale. [4] Sampled at the feeder apron. [5] Sampled after ginning but before lint cleaning.